Appendix A

# Optimization of CCD Microlens Size for Color Balancing

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## Field of Invention

This invention relates to electronic imaging, and in particular the color sensitivity of individual pixels in a CCD.

## Background of Invention

The responsivity of a CCD typically varies with the wavelength of the incident light. This variation is caused by a variety of factors including the gate electrode and dielectric stack, color filter non-idealities, and the sensitivity of the silicon itself. Typically, the spectral response of a CCD peaks in the green and is lowest in the blue. There is also much less blue light available in typical scenes making larger sensitivity to blue light desireable. This invention preferentially directs portion of the light that would otherwise be captured by pixel with high responsivity onto a pixel with lower response and thus permit optimization of the total spectral sensitivity of the device.

## Summary of the Invention

Microlens arrays deployed on CCDs are typically sized identically for each color and match the dimension (less the gap between lenses) of the underlying pixel. By uniquely sizing the microlenses over each color, (and expanding outside the bounds of the underlying pixel if necessary), the spectral response of the device can be customized.

## Advantages over Prior Art

* Improved color balance without significant loss of light
* Improved blue response
* Less sensitivity to lens inefficiencies when applied to a full frame CCD

## Detailed Description of the Invention

A typical lens array is shown in figure 1. An example of a resized lens array is shown in figure 2. In the (somewhat exaggerated) case shown, an oversized blue lens focuses a percentage of the light that would have been collected in the green pixel using the standard design in figure 1. This additional light can be used to compensate for spectral sensitivity differences. Due to changes in the curvature of the lens as function of lens size, not all lenses will focus light on the substrate with equal efficiency. When applied to an interline CCD with a narrow photodiode, this will reduce the quantum efficiency of these pixels, but still improve color balancing. In the case of full frame image sensors (where the entire pixel is photosensitive), these losses (if any) will be much less severe since the diameter of the focus spot of the lens is less critical.

Examples of Prior ART:

US PAT. 4,667,092 ← USE OF LENSLETS

US PAT. 6,001,668 (KODAK) ← ITO FULL FRAME SENSOR w/ MENTION OF LENSLET TO FOCUS LIGHT INTO ITO PHASE

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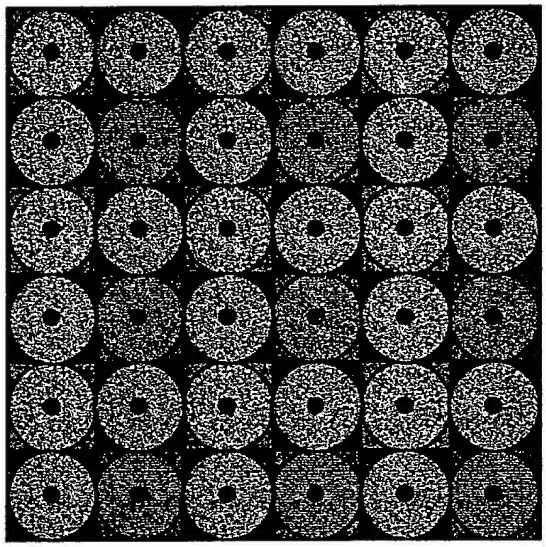
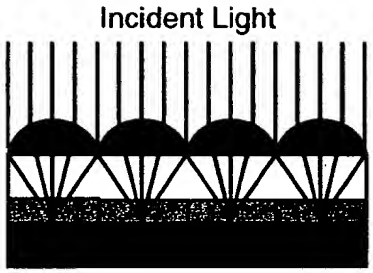
## Attachments

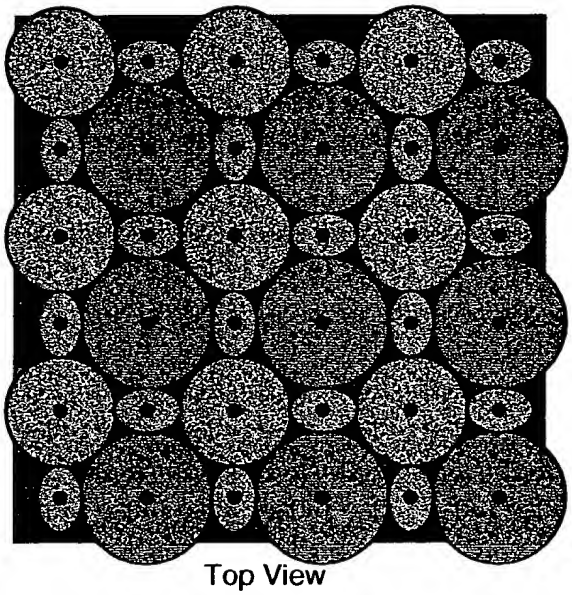


Top View

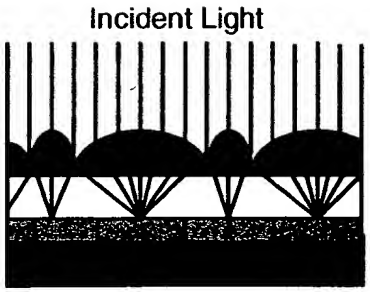



Cross Sectional View

**Figure 1**



Top View




Cross Sectional View

**Figure 2**

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